The Ubiquity of Non-Neutrality

Francesco Caselli

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Production Functions

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$$F_{ct}(X_{1ct}, X_{2ct}, ...) = G(A_{1ct}X_{1ct}, A_{2ct}X_{2ct}, ...)$$

Choice of Inputs and Functional Form

$$Y_{ct} = \left[(A_{Kct} K_{ct})^{\sigma} + (A_{Lct} L_{ct})^{\sigma} \right]^{1/\sigma}$$

$$L_{ct} = \left[(A_{Uct} U_{ct})^{\rho} + (A_{Sct} S_{ct})^{\rho} \right]^{1/\rho}$$

$$K_{ct} = \left[(A_{Nct} N_{ct})^{\eta} + (A_{Mct} M_{ct})^{\eta} \right]^{1/\eta}$$

Factor Bias Term

$$X_{ct} = \left[(A_{1ct} X_{1ct})^{\zeta} + (A_{2ct} X_{2ct})^{\zeta} \right]^{1/\zeta}$$

$$\frac{MP_{1ct}}{MP_{2ct}} = \left(\frac{A_{1ct}}{A_{2ct}} \right)^{\zeta} \left(\frac{X_{1ct}}{X_{2ct}} \right)^{\zeta - 1}$$

Biased Technological Change

$$\text{Corr}\left[\left(\frac{A_{1ct}}{A_{2ct}}\right)^{\zeta}, t\right]$$

Biased Technology Differences

$$\text{Corr}\left[\left(\frac{A_{1ct}}{A_{2ct}}\right)^{\zeta}, Y_c\right]$$

Overview (1)

- Skill bias

$$\text{Corr}\left[\left(\frac{A_{Sc}}{A_{Uc}}\right)^{\rho}, Y_c\right], \text{Corr}\left[\left(\frac{A_{St}}{A_{Ut}}\right)^{\rho}, t\right] > 0$$

- Reproducible-Capital Bias

$$\text{Corr}\left[\left(\frac{A_{Mc}}{A_{Nc}}\right)^{\eta}, Y_c\right] > 0$$

- Capital Bias

$$\text{Corr}\left[\left(\frac{\tilde{A}_{Kc}}{\tilde{A}_{Lc}}\right)^{\sigma}, Y_c\right], \text{Corr}\left[\left(\frac{\tilde{A}_{Kt}}{\tilde{A}_{Lt}}\right)^{\sigma}, t\right] > 0$$

- Experience Bias

Overview (2)

$$\begin{aligned} \text{Corr}\left[\tilde{A}_{Lc}, Y_c\right], \text{Corr}\left[\tilde{A}_{Lt}, t\right] &> 0 \\ \text{Corr}\left[\tilde{A}_{Kc}, Y_c\right], \text{Corr}\left[\tilde{A}_{Kt}, t\right] &< 0 \end{aligned}$$

Method

$$X_{ct} = \left[(A_{1ct} X_{1ct})^{\zeta} + (A_{2ct} X_{2ct})^{\zeta} \right]^{1/\zeta}$$

$$\frac{MP_{1ct}}{MP_{2ct}} = \left(\frac{A_{1ct}}{A_{2ct}} \right)^{\zeta} \left(\frac{X_{1ct}}{X_{2ct}} \right)^{\zeta - 1}$$

Method

$$X_{ct} = \left[(A_{1ct} X_{1ct})^{\zeta} + (A_{2ct} X_{2ct})^{\zeta} \right]^{1/\zeta}$$

$$\frac{P_{1ct}}{P_{2ct}} = \left(\frac{A_{1ct}}{A_{2ct}} \right)^{\zeta} \left(\frac{X_{1ct}}{X_{2ct}} \right)^{\zeta - 1}$$

Skilled and Unskilled Labor (across countries)

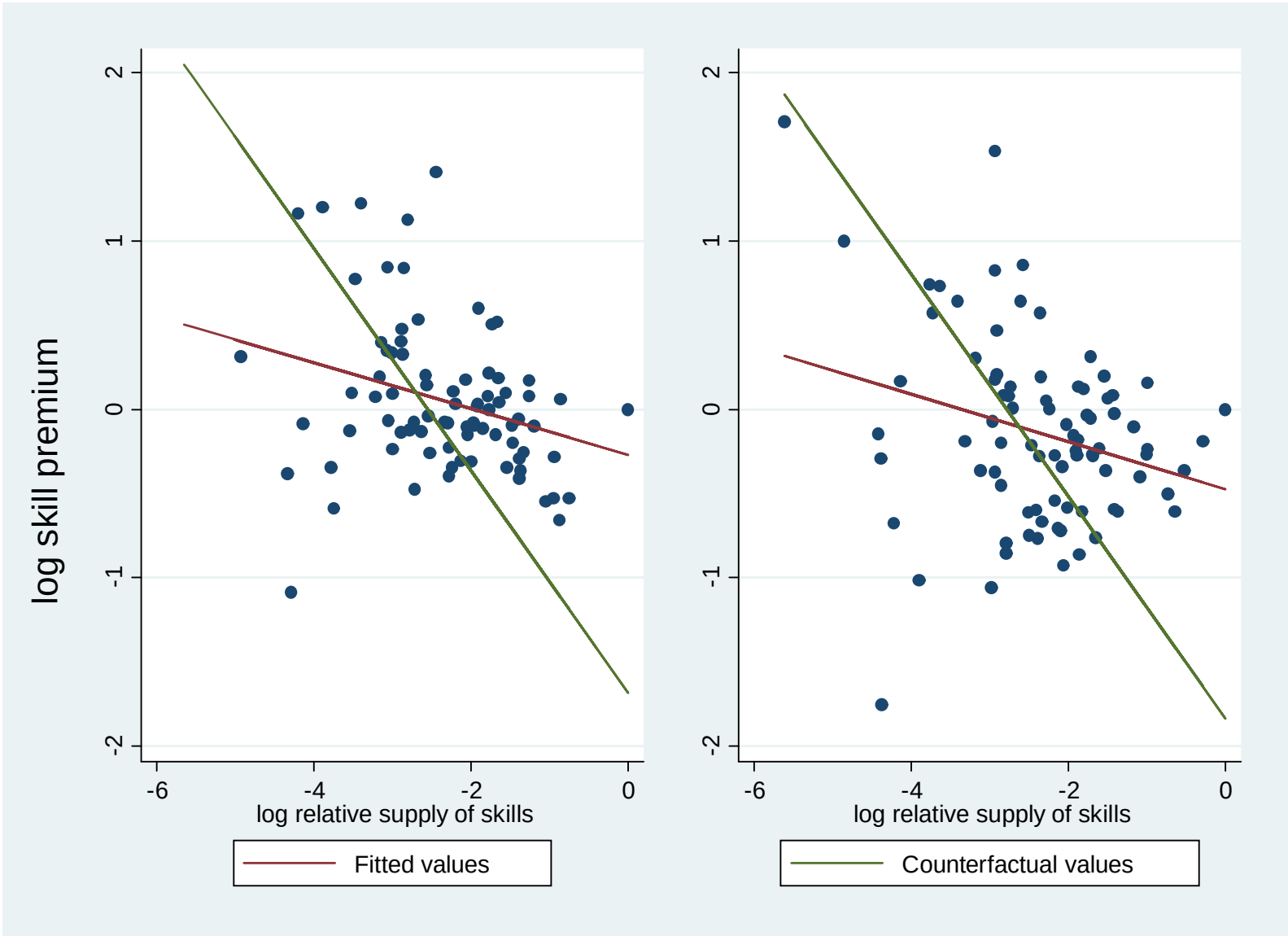
$$\frac{W_{Sc}}{W_{Uc}} = \left(\frac{A_{Sc}}{A_{Uc}}\right)^{\rho} \left(\frac{S_c}{U_c}\right)^{\rho-1}$$

Relative Skill Supply Across Countries

Skill Premium Across Countries

Skill Bias Result

Why the Data Want Bias



$$\text{Counterfactual} = (\rho - 1) \log \left(\frac{S}{U} \right)$$

Natural and Reproducible Capital

$$K_{ct} = \left[(A_{Nct} N_{ct})^{\eta} + (A_{Mct} M_{ct})^{\eta} \right]^{1/\eta}$$

$$\frac{MPM_c}{MPN_c} = \left(\frac{A_{Mc}}{A_{Nc}} \right)^{\eta} \left(\frac{M_c}{N_c} \right)^{\eta - 1}$$

Reproducible/Natural Capital Across Countries

Relative Marginal Productivities Across Countries

Reproducible Capital Bias Result

$$Corr\left(\left(\frac{A_{Mc}}{A_{Nc}}\right)^{\eta}, Y_c\right) > 0 \text{ if } \frac{1}{1-\eta} \leq 3$$

Up One Level

$$Y_c = \left[\left(\tilde{A}_{Kc} \tilde{K}_c \right)^{\sigma} + \left(\tilde{A}_{Lc} \tilde{L}_c \right)^{\sigma} \right]^{1/\sigma}$$

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$$Y_c = \left[\left(\tilde{A}_{Kc} \tilde{K}_c \right)^{\sigma} + \left(\tilde{A}_{Lc} \tilde{L}_c \right)^{\sigma} \right]^{1/\sigma}$$

$$\begin{aligned} \tilde{W}_c &= \left(\tilde{A}_{Lc} \right)^{\sigma} \left(\frac{Y_c}{\tilde{L}_c} \right)^{1-\sigma} \\ \tilde{R}_c &= \left(\tilde{A}_{Kc} \right)^{\sigma} \left(\frac{Y_c}{\tilde{K}_c} \right)^{1-\sigma} \end{aligned}$$

Absolute Efficiency

$$\begin{aligned}
\tilde{A}_{Lc} &= \left(\frac{\tilde{W}_c \tilde{L}_c}{Y_c}\right)^{1/\sigma} \frac{Y_c}{\tilde{L}_c} \\
\tilde{A}_{Kc} &= \left(\frac{\tilde{R}_c \tilde{K}_c}{Y_c}\right)^{1/\sigma} \frac{Y_c}{\tilde{K}_c}
\end{aligned}$$

Labor Share

Figure:

Absolute Efficiency

$$\tilde{A}_{Lc} = \left(\frac{\tilde{W}_c \tilde{L}_c}{Y_c}\right)^{1/\sigma} \frac{Y_c}{\tilde{L}_c}$$

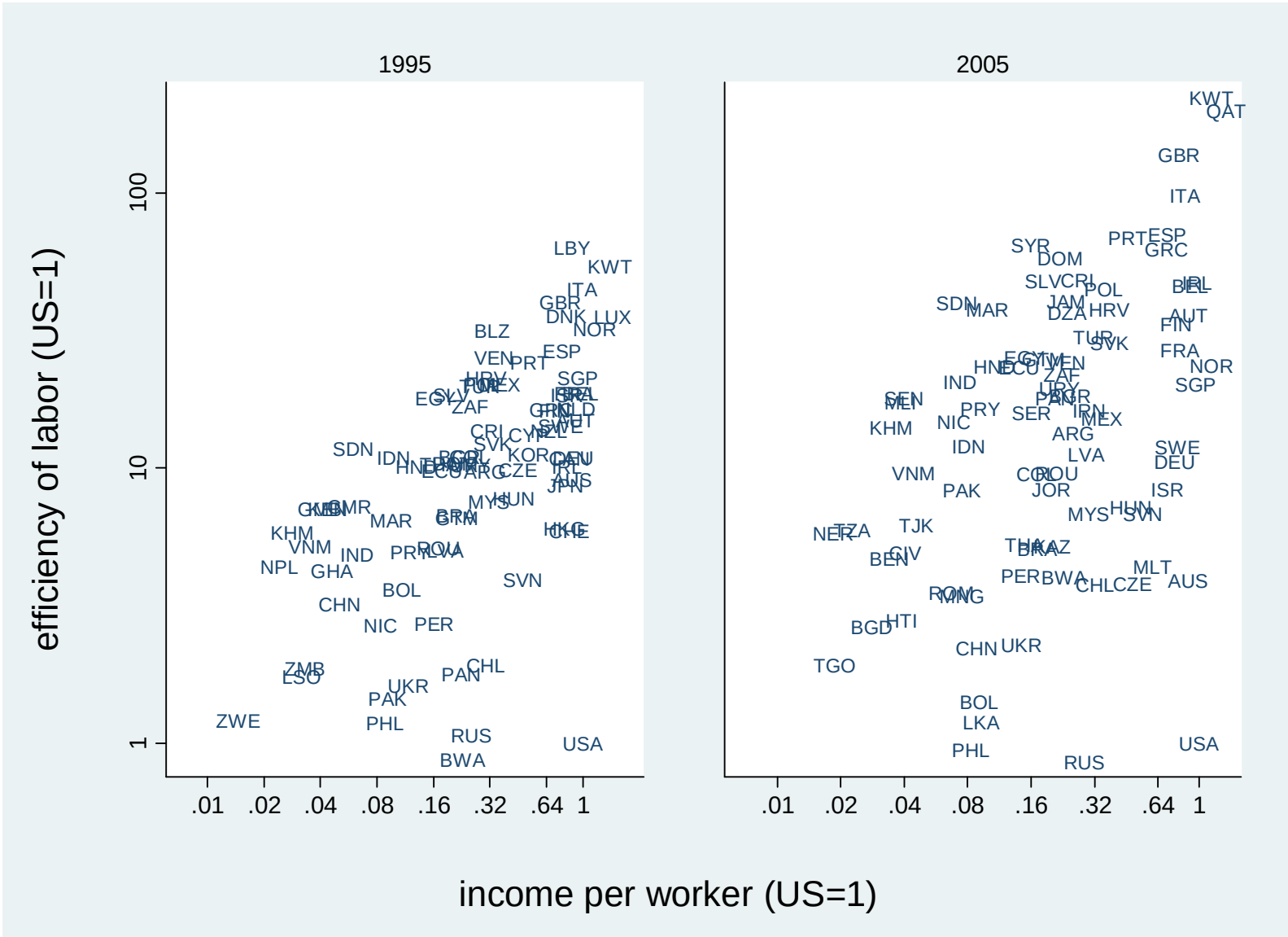
$$\tilde{A}_{Kc} = \left(\frac{\tilde{R}_c \tilde{K}_c}{Y_c}\right)^{1/\sigma} \frac{Y_c}{\tilde{K}_c}$$

Absolute Efficiency

$$\tilde{A}_{Lc} = \text{constant}_1 \text{ x } \frac{Y_c}{\tilde{L}_c}$$

$$\tilde{A}_{Kc} = \text{constant}_2 \text{ x } \frac{Y_c}{\tilde{K}_c}$$

Efficiency of Labor

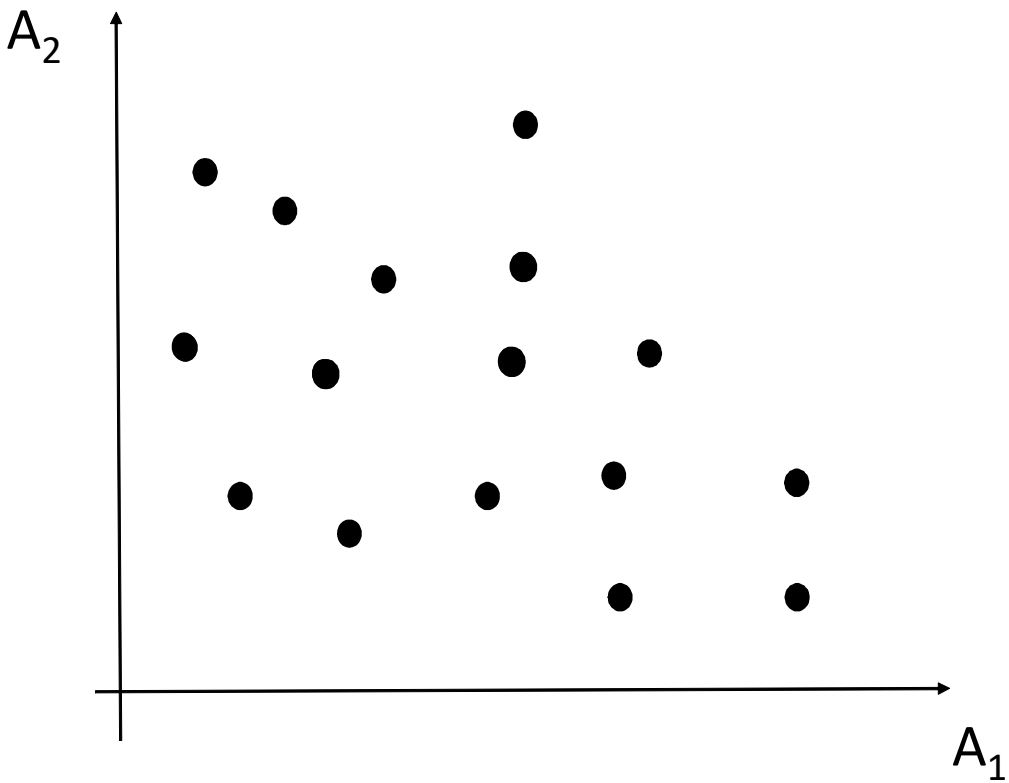


Efficiency of Capital

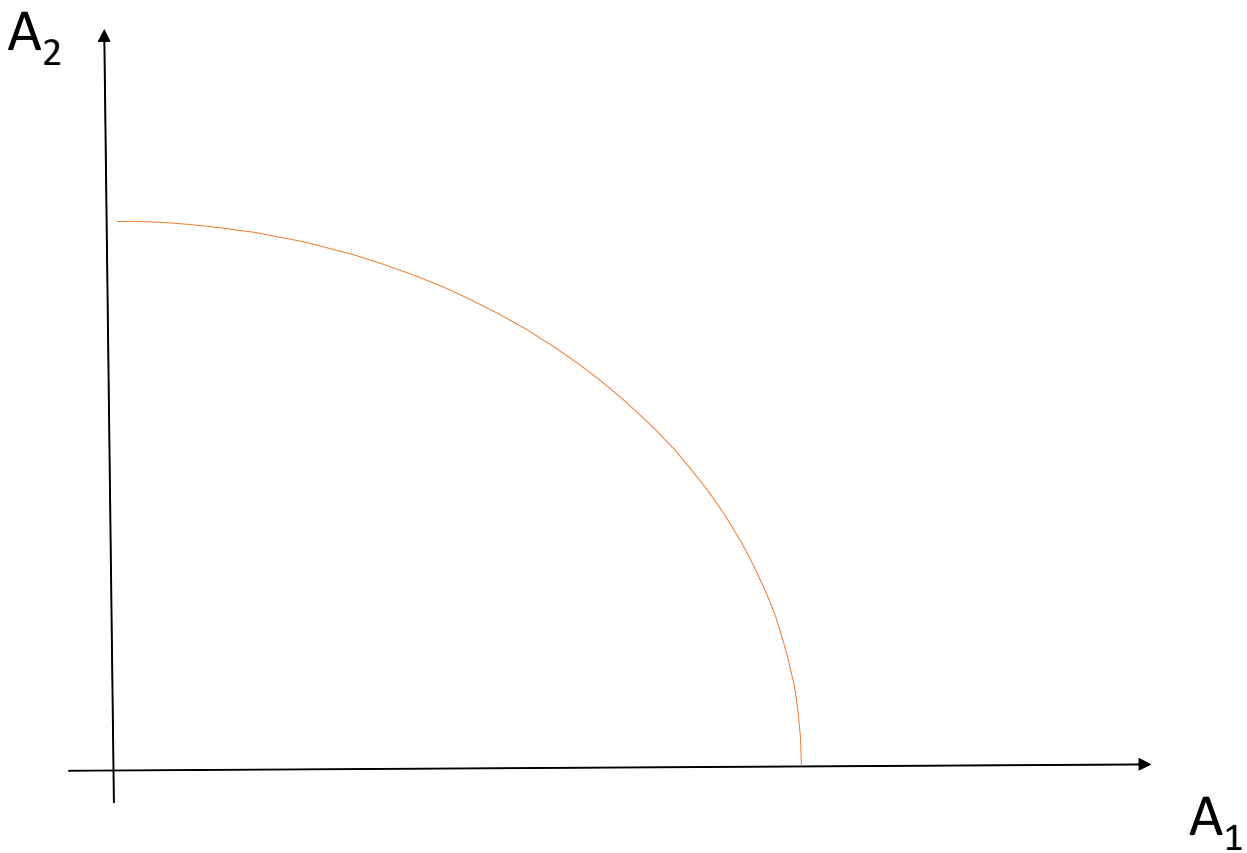
Capital Bias Result

$$Corr\left(\left(\frac{\tilde{A}_{Kc}}{\tilde{A}_{Lc}}\right)^{\sigma}, Y_c\right) > 0 \text{ if } \frac{1}{1-\sigma} < 1$$

Technology Choice



Technology Frontier



Firm Problem

$$\max_{X_1, X_2, A_1, A_2} \left[(A_{1ct} X_{1ct})^{\zeta} + (A_{2ct} X_{2ct})^{\zeta} \right]^{1/\zeta} - P_1 X_1 - P_2 X_2$$

$$\text{s.t. } A_1, A_2 \text{ within frontier}$$

Implications of Model (1)

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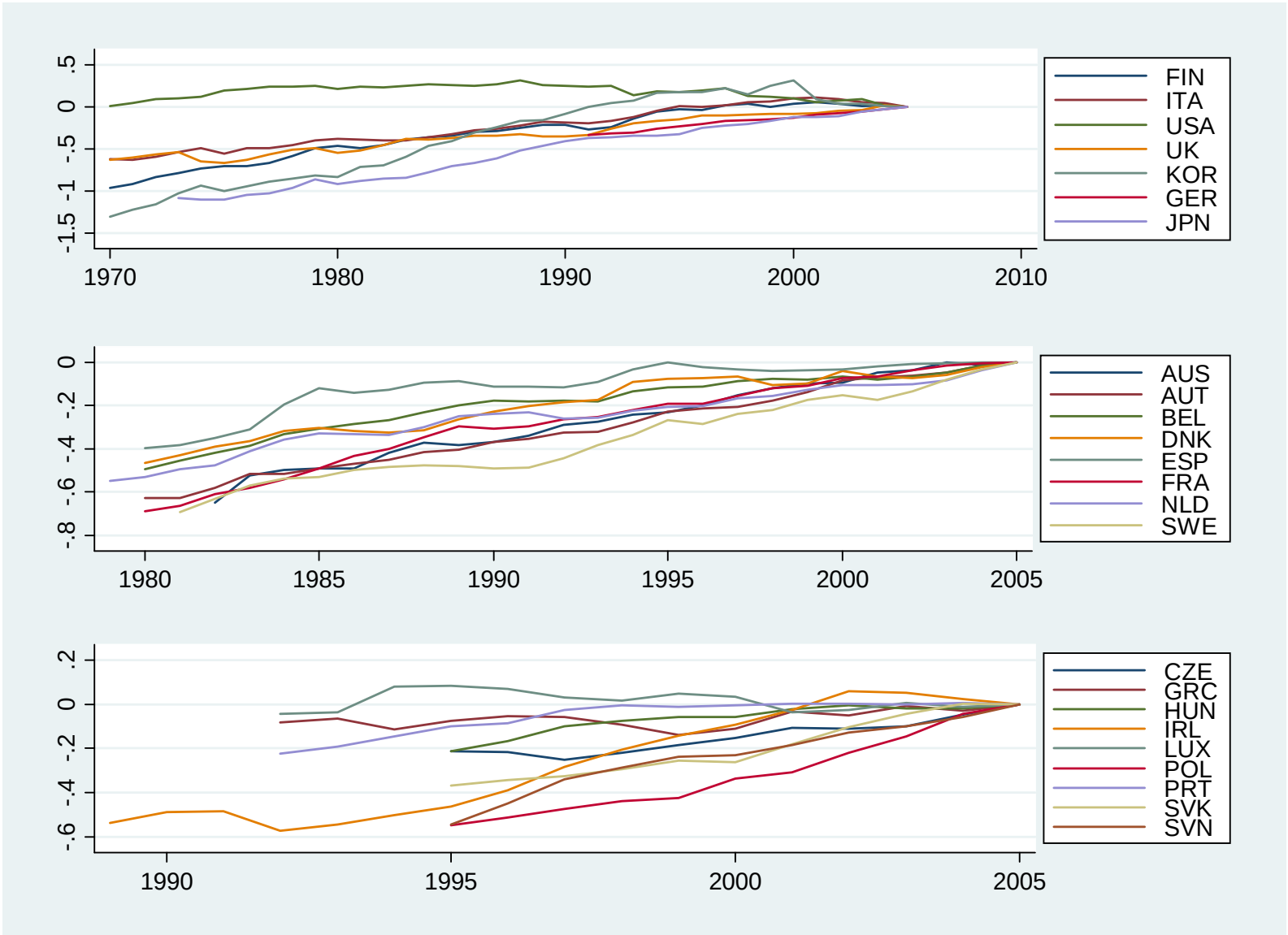
- If EOS <1, efficiency declines with relative abundance
- $\text{Corr}\left(\tilde{A}_K, \frac{\tilde{K}}{\tilde{L}}\right) < 0$ $\surd$
- $\text{Corr}\left(\tilde{A}_L, \frac{\tilde{K}}{\tilde{L}}\right) > 0$ $\surd$

Labor Efficiency Over Time



Capital Efficiency Over Time